URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS

12-7A-2
Fire Resistive Standards for
EXTERIOR WINDOWS

STATE FIRE MARSHAL

(a) ***Application.*** *The minimum design, construction and performance standards set forth herein for exterior windows are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A.*

(b) Scope. *This standard evaluates the performance of exterior windows used in structures when exposed to direct flames.*

(c) Referenced Documents.

1. *AAMA Training Manual, Residential & Light Commercial Window and Door Installation Training and Registration Program.*
2. *California Building Code, Chapter 7A*

(d) Definitions.

1. ***Glazing****. The glass in a window, which may include layers of plastic as well as glass.*
2. ***Sash****. The fixed or movable parts of the window in which the panes of glass are set.*
3. ***Frame (Jambs)****. This usually consists of two vertical members (side jambs) and two horizontal members (head and sill) that hold the sash.*

(e) Equipment.

1. ***Burner****. A 4 x 39 in. (100 x 1000 mm) propane diffusion burner shall be used. For windows wider than 39 in. (1 m), the burner width should be increased to match the window width.*
2. ***Infrared temperature analyzer*** *(optional). Intended for monitoring the temperature change of the inside of the window assembly.*

(f) ***Materials****. In the absence of the window manufacturer's specifications, the wall assembly shall include the following minimum components:*

1. ***Windows****. The window may be any type or size that fits within the wall (see (g).1.ii).*
2. ***Framing****. 2 x 4 studs*
3. ***Gypsum board****. Non-combustible mounting around the window.*
4. ***Gypsum trim****. Pieces of gypsum cut into narrow strips for use as trim around the window.*
5. ***Caulk****. Caulking to be applied as per the window manufacturer's instructions.*

(g) Test system preparation (Figure 1).

1. ***Wall Module****.*
   i). The module shall be designed to permit rapid installation and removal of window/wall assemblies and have two non-combustible side walls, and a non-combustible simulated soffit.
   ii). The assembly shall permit rear insertion of a pre-fabricated 4 x 8 ft (1.2 x 2.4 m) wall section containing the test window. The bottom edge of the window shall be 24 in. (450 mm) from the top of the burner.
   iii) Larger windows may be tested by expanding the size of the rear wall of the Wall Module, and the length of burner.
2. ***Window framing****. Provide a framed rough opening following manufacturer guidelines. Apply manufacturer recommended caulk to nailing flange prior to installation.*
3. ***Window installation****. Fit the window into the rear wall of the Wall Module, referring to AAMA Training Manual or equivalent.*
4. ***Sealing****. Seal all edges, including the soffit-to-wall joint using ceramic wool or comparable material to prevent flame penetration at the edges.*
5. ***Trim****. Use narrow strips of gypsum board as trim around window, covering the nail flange of the window.*
6. ***Finish****. Apply finish to exposed portion of window frame if recommended by window manufacturer****.***

(h) Conduct of Tests.

1. ***Airflow.*** *The window test shall be conducted under conditions of ambient airflow.*
2. ***Number of tests****. Conduct the tests on three replicate window assemblies.*
3. ***Burner Output Verification****. Without the window in place, adjust the burner for 150 ± 8 kW output. Extinguish the burner.*
4. ***Burner configuration****. Center the burner relative to the width of the window-wall assembly and against the wall. The distance from the floor to the top of the burner shall be 12 in. (300 mm).*
5. ***Procedure.***
   i). Ignite the burner, controlling for a constant 150 ± 8 kW output.
   ii). Continue the exposure until flame penetration or structural collapse occurs, or for a 10-min period
   iii). If penetration or collapse does not occur, continue observation for an additional 30 min or until all combustion has ceased. An infrared thermometer has been found to be useful to detect the increase of temperature on the back side of the windows and an aid to identify the areas of potential combustion.
6. ***Observations****. Note the development of any fissures or holes in the frames or glazing, and time and location of any penetration of flames through frames or glazing.*

(i) ***Report****. The report shall include a description of the window unit, including the types of frames, cladding and panes being tested, and details of the installation. Record when and how the glass fractured or flame-through occurred in the framing materials or sash, and/or if the framing material deformed or otherwise suffered a loss of integrity such that the glass could not be held in place, and a record of the time at which any of these events occurred. Provide details on the time and reasons for early termination of the test.*

(j) Conditions of Acceptance. *Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.*

1. *Absence of flame penetration of windows during the test****.***
2. *Absence of structural failure of the frame or glazing, or gaps or fissures greater than 0.25 x 6 in. (6 x 150 mm).*
3. *Absence of flaming or glowing combustion of the framing at the conclusion of the 40-min test.*

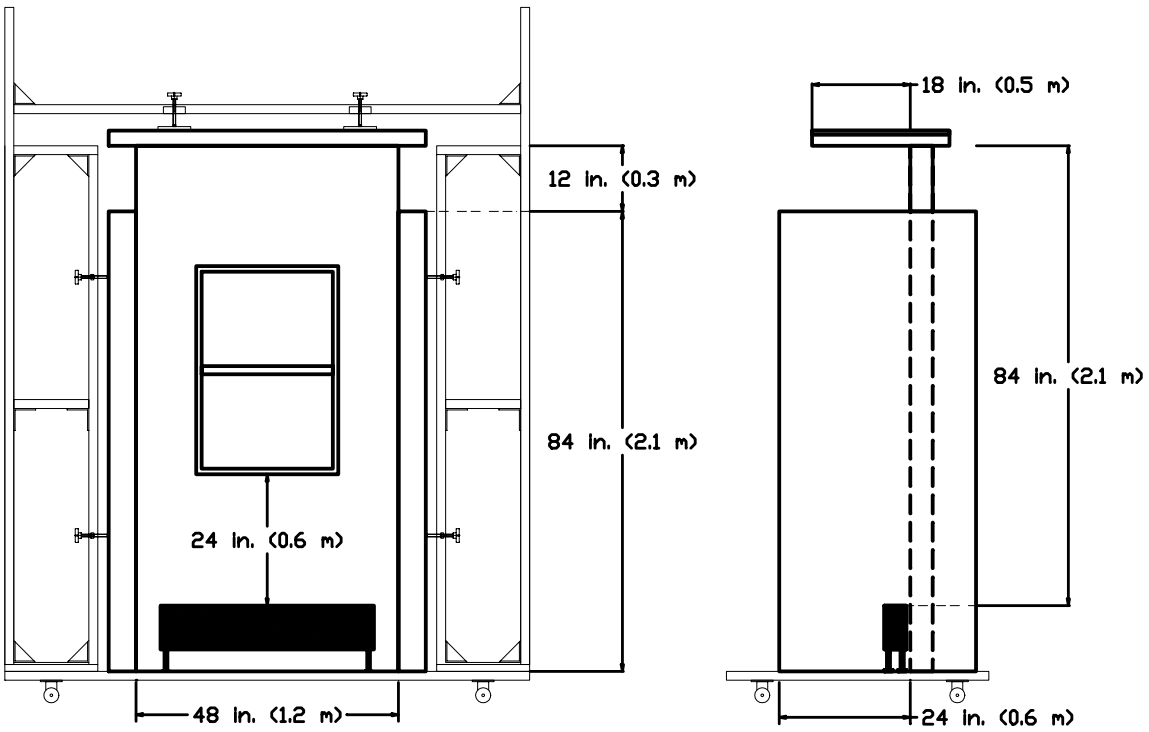

Figure 1. Window-Wall Test Assembly

COMMENTARY: EXTERIOR WINDOWS

Purpose. This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

The research by UCFPL started in 1995; at the completion, after about four years, the work was reviewed by a committee of California fire authorities who prepared a report intended to lead to model building codes. However, the movement to code was delayed until 2004, when the California Legislature (through AB1216) directed OSFM to complete the code work by 1 January 2005. Under the administration of OSFM, the test protocols developed by UCFPL were written into Standards language.

Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to "certify" materials and/or assemblies, but to provide guidance in the development of the test protocols and for the "conditions of acceptance." Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire.
Windows are one of the most vulnerable portions of a structure exposed to fire because of the possible loss of integrity, permitting brands or flames to gain entry. This vulnerability is due to a number of factors. Impact of airborne debris or the thermal shock of direct flame impingement may fracture the glass, permitting burning brands or flames to gain entry into the building. The window frame is also susceptible to burn-through under direct flame exposure. Radiant or convective heating--from an adjacent burning structure, for example--might not break the glass but could ignite or deform the window frame, permitting the glass to fall out and again exposing the building to subsequent entry of flames.

The vulnerability of windows is closely related to their orientation and location. Since most windows are vertically oriented (skylights are an exception), this would cause exposure to the maximum level of radiation. One of possible sources of a very high level radiation is an adjacent structure that is involved in fire. Ground level windows are also exposed to combustible fuels that may be adjacent to a structure, including ornamental plants, decks, and stored materials. Also, if the structure has combustible siding, this represents another source of fire that can even extend to upper level windows.

In addition to orientation and location, windows have construction characteristics that make prescriptive recommendations impractical. These include glass resistance to heat and breakage, number of lights (single, double, triple glazing), the type of frames (fixed, casement, sliding, hung, etc), framing materials (wood, plastic, fiberglass, aluminum; and combinations of these), and installation (details, including that for replacement windows).

Development of the Test Protocol.
In preliminary tests, the exposure was 150 kW for 3 min and 150 kW to failure. The former exposure is considered the minimum that a window might receive from a small ornamental plant directly under the window and were conducted to see if the various frame materials would sustain combustion and fail after removal of the flame. The latter exposure was conducted to determine the category of failure (glass or frame).

Materials.
Since there are so many potential combinations of frame material, frame type, and glass type/configuration, only a relatively few possibilities could be tested (Table 1). Commercially-available 2 x 3 ft (600 x 900 mm) window units were purchased from a local retailer. A full range of frame materials for single- or double-hung windows with double-pane glass was selected, several fixed windows, and those with single-pane glass.

Tests.
The windows were installed in a window-wall assembly that permitted rapid installation and removal of and designed to prevent edge penetration of fire at the margins. It includes two adjustable non-combustible side walls attached to a wall frame assembly, and a non-combustible floor and adjustable simulated soffit. The windows were subjected to fire performance testing by exposure to the 150 kW burner placed against the wall below the window. Several special tests were conducted with 300 kW flame-impingement exposure to determine the effects of an extreme exposure on glass and the effectiveness of screens as a “fire barrier.”

Results.
Failures were defined as loss of glass that could enable flame penetration, or penetration of fire through the frames. Glass failures occurred in 3 of 13 tests when exposed to 150 kW for 3 min (all occurred in less than 2 min). Of 6 exposed to 150 kW to failure, all failed in a range of 6 to 9 min (the three types of windows that failed in the 3-min exposure were not included in the test to failure). For resistance to flame impingement, *double-pane glass* is the clear choice, as can be seen from the data in Table 2. Tempered glass also appears to perform somewhat better than annealed, but the results are not definitive. The 300 kW flame impingement tests with metal screens in place (data not shown) indicated little, if any, protection to the glass.

Comments.
Since glass failure--not frame failure--was responsible for the termination of most the flame impingement tests, it was not possible to discern performance differences among the frame materials. However, other research has reported that radiant exposure can deform some double-hung vinyl window frames so that the glass falls out. The sensitive element in such a window is the horizontal interlock where the upper and lower sashes meet. In windows tested, and generally in larger vinyl windows, this interlock is aluminum reinforced (for protection against wind deformation), which may protect against this type of failure.

The marginal difference between annealed and tempered glass in the two exposure intensities should not be considered an endorsement for annealed glass, since tempered glass is expected to offer impact resistance to flying debris.

Although metal screens indicated little, if any, protection to the glass, previous studies have shown that they provide some shielding against radiant heat exposure. They would also be expected to protect the window somewhat from impact by flying debris.

Two areas not tested—radiant exposure and impact—will require protocol development and testing in the future to amend the Standard.

Conditions of acceptance.
The conditions of acceptance are more rigorous than the testing would support, since it was felt that windows must have the same exposure conditions (150 kW for 10 min) as do external walls in SFM-1. In support of these conditions, there were clear indications in the testing that window manufacturers should be able to make appropriate modifications to meet the provisions of the Standard.

Table 1. Windows selected for testing

Glass	Wood	Aluminum clad wood	Vinyl clad wood	Vinyl (aluminum-reinforced)	Aluminum	Fiberglass	Aluminum clad wood	Vinyl
Single pane (annealed)		H						
Single pane (tempered)		H						
Double pane (annealed)	H	H	H	H	H	H	F	F
Double pane (tempered)		H		H				

H = Single/double hung
F = Fixed

Table 2. Window construction and results

Frame Type	Frame material	Glass Type	150 kW failure (min) location***	300 kW failure (min) glass
Single/double hung	Aluminum-clad wood	Single-pane (annealed)	1:30 (g) 8:50 (f)	0:33
Single/double hung	Aluminum-clad wood	Single-pane (tempered)	8:15 (f)	1:15
Single/double hung	Vinyl (aluminum-reinf.) (Milgard)	Single-pane (annealed)	6:51 (g)	2:10
Single/double hung	Vinyl (aluminum-reinf.) (Milgard)	Double-pane (tempered)	6:00 (g)	2:45
Single/double hung	Vinyl (aluminum-reinf.) (JeldWen)	Double-pane (tempered)	6:00 (f)	2:58
Single/double hung	Aluminum-clad wood	Double-pane (annealed)	5:55 (f)	1:09
Single/double hung	Wood	Double-pane (annealed)	1:45 (g)	1:46
Single/double hung	Vinyl-clad wood	Double-pane (annealed)	1:45 (g)	1:05
Single/double hung	Aluminum-clad wood	Double-pane (tempered)	3:00**	3:07
Single/double hung	Aluminum	Double-pane (annealed)	3:00**	2:56
Single/double hung	Fiberglass	Double-pane (annealed)	3:00**	6:28
Fixed	Aluminum-clad wood	Double-pane (annealed)	3:00**	3:45
Fixed	Vinyl	Double-pane (annealed)	3:00**	1:20

* Time is the average of test replicates. If the failure location in replicate tests was different, both times are given.
** Tests of frame materials for sustained combustion. 150 kW flame exposure stopped at 3 min; no failure observed
*** Failure in glass (g) or frame (f)